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EXPERIMENTAL ANALYSIS OF HYBRID CARBON FIBER COMPOSITE SPECIMEN

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Abstract - *This paper focused on experimental study of hybrid composite specimens prepared according to ASTM standards. Composites are the formed by the combination of reinforcement and matrix, which exibits better properties compared to that of individual components. Because of its low density characteristics, composites has got a wide range of applications. Composites are classified mainly as natural and artificial ones depending on the type of reinforcement used. The cost of artificial ones are quite higher compared to natural ones, but because of their better strength, corrosion resistance and less maintenance requirements they are mostly preferred.*

The specimens are prepared by means of hand lay-up process considering ASTM D 3039 and ASTM 790 standards. UTM tensile load test as well as flexure (3 point bending) tests are conducted on the prepared specimen. From the results, better material is selected for further applications.

Key Words: Hybrid, Reinforcement, Matrix, Hand lay-up.

1.INTRODUCTION

Composites (also known as composition material) are combination of two or more constituent materials called as matrix and reinforcement, when combined together produce a material having different characteristics than that of individual components. They are combined in such a way that they remain separate and distinct within the finished structure because they don't fully merge or dissolve into one another. Composites can be preferred for so many reasons: because of its high strength, low density as well as good corrosion resistance compared to that of traditional materials.

Depending on the type of reinforcement, composites can be classified as natural and artificial ones. Natural composites are generally preferred because of their cheap availability as well as low cost. But considering the strength part, artificial reinforcements exibits very good properties than natural ones. Among artificial fibers, carbon fibers exibits very high strength properties compared to other materials, but the high cost of carbon fiber makes it difficult for widening its application. In order to make it economical, the idea of hybrid composite specimens are implemented. For that, E-glass and Kenaf reinforcements are combined with carbon fiber reinforcement because these materials are cheaply available with reasonable cost and also have good strength properties.

The E-glass and Kenaf fibers were preferred because of its better tensile strength compared to other materials and of low cost. Kenaf is a natural fiber made from hibiscus stem, found in African forests mostly have higher tensile strength corresponds to that of other natural fibers presently available and since it is natural fiber, cost is comparatively low. Also the matrix used was mixture of epoxy resin L-12 (Lapox 12, based on bisphenol A) and 407 hardener (low density filler).

Table -1: Material Properties

Properties	Carbon Fiber	E glass Fiber	Kenaf Fiber
Density (g/cm^3)	1.4	2.55	1.45
Elastic Modulus (GPa)	230-240	71	53
Tensile Strength (MPa)	4000	1700	930
Specific Stiffness (GPa)	128-170	28	37

2. HAND LAY-UP PROCESS

Hand Lay-up process was the method employed for the hybrid composite formation. It is the simplest method for the preparation of composites. The infrastructural requirement is also minimal for this method. The processing steps are quite simple and are follows.

- Initially, put thin plastic sheets as the base to get good surface finish of the product.
- Reinforcement in the woven mats or chopped strand mats form are cut as per the required size of 20 x 20 mm.

- Prepare the matrix by mixing resin and hardener in a proper ratio and spread it over plastic sheets provided as base by means of a brush.
- Now place the reinforcement above resin applied at the plastic sheet. The resin should spread properly by means of rollers to get a good base and also excess resin can be removed by the usage of rollers.
- Apply resin over the base layer and place layers in alternate order by placing resin in between them and roll it effectively.
- The top portion of the stacked composite is covered by means of a plastic sheet and finish it using rollers.
- The prepared specimen is kept at room temperature and proper loading is provided for one day.
- After a day, the loads are removed and the developed composite part is taken out.
- The curing time mainly depends upon the type of polymer used for composite formation.
- The prepared stacked composite specimen is cut into ASTM standard specimens by means of a cutter.

Since the focus of the paper was to minimise the cost as well as to obtain better property than laminate composites, 40% Carbon fiber was used in the specimen along with 60% of E glass/Kenaf.

3. EXPERIMENTAL TESTS CONDUCTED

3.1 UTM Tensile Load Test

In order to evaluate basic properties of engineering materials as well as in developing new materials and in controlling the material quality for design use and construction, mechanical testing plays a major role. It is important for a material to identify whether it is strong and rigid enough to withstand the loads when it is used as part of an engineering structure. A number of experimental techniques have been developed to find mechanical behaviour of engineering materials, when the materials are subjected to tensile, compressive, and bending as well as torsion loading.

Tensile Load Test is the most common type of test used for measuring the mechanical properties of materials. This test is widely used to provide a basic design information regarding material properties and is generally accepted test for material specifications. The major parameters obtained during the tensile load test are the tensile strength (UTS), yield strength (σ_y), Elastic modulus (E), percent of increase in length ($\Delta L\%$) and the percentage of reduction in area (RA%). Toughness, Poisson's ratio (ν) etc. can be found out using this technique.

In this test, a specimen is fixed between the jaws of the testing machine before loading. The specimen used is approximately uniform over the length within which elongation measurements are done (gauge length). Tensile specimens are developed according to the ASTM standards. The cross section of the specimen is rectangular in shape. The change in gage length of the sample as tensile loading proceeds is measured from a sensor attached to the sample (*called an extensometer*) or by the change in actuator position (*stroke or overall change in length*).

The tensile loading is done to the specimen until it fractures. During the test, the maximum load is recorded. By using an x-y recorder, a load elongation curve is plotted in order to find the tensile behaviour of the material. An engineering stress-strain curve is also obtained along with the load-deflection curve and the required mechanical parameters can be obtained by studying on this curve.

Fig -1: UTM Tensile load Test

3.2 Flexure (3 Point Bend) Test

The three point bending flexural test provides values for the bending modulus E_f, flexural strength σ_f, flexural strain ε_f and the flexural (bending) stress-strain response of the material. The ease of the specimen preparation and testing is main advantage of a three-point flexural test. However, the results of the testing method are sensitive to specimen and loading geometry along with strain rate which are certain disadvantages of this method.

The method for conducting the test usually involves a specified test fixture on a universal testing machine. The sample is placed at a set distance apart on two supporting pins and a third pin is provided for loading purpose lowered from above at a constant rate until failure of sample.

Fig -2: Flexure Test

4. TEST RESULTS

4.1 UTM Tensile Load Test Results

Tensile Load vs. Deflection

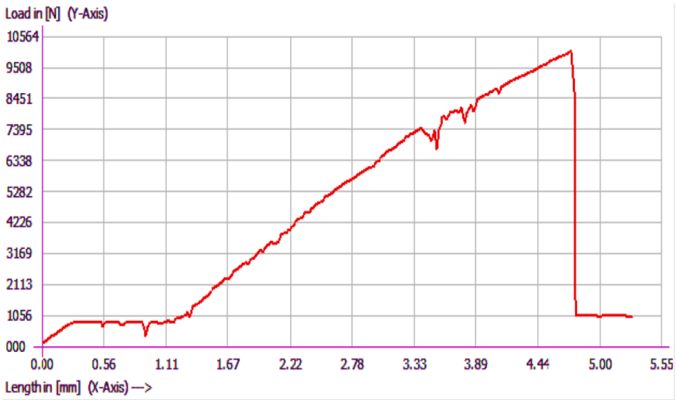

Chart -1: Carbon – Kenaf Hybrid

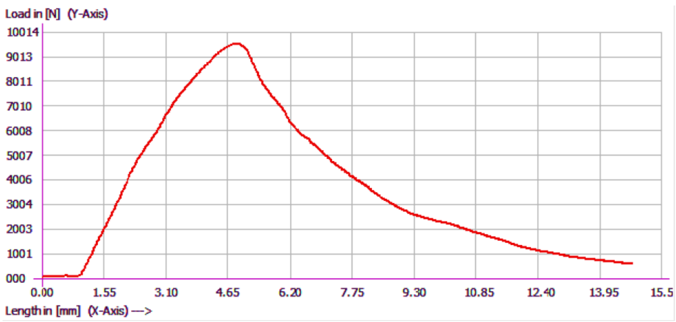

Chart -2: Carbon – E glass Hybrid

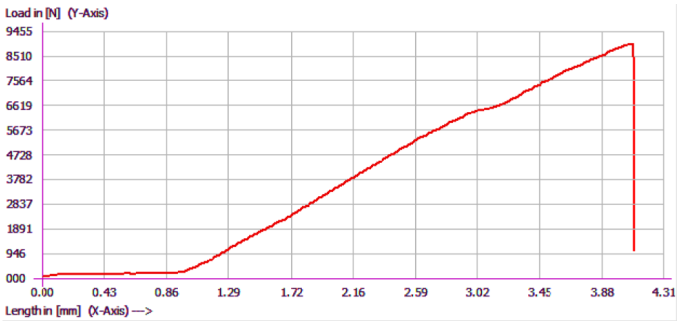

Chart -3: Carbon Fiber alone

4.2 Flexure (3 Point Bend) Test Results

Bending Load vs. Deflection

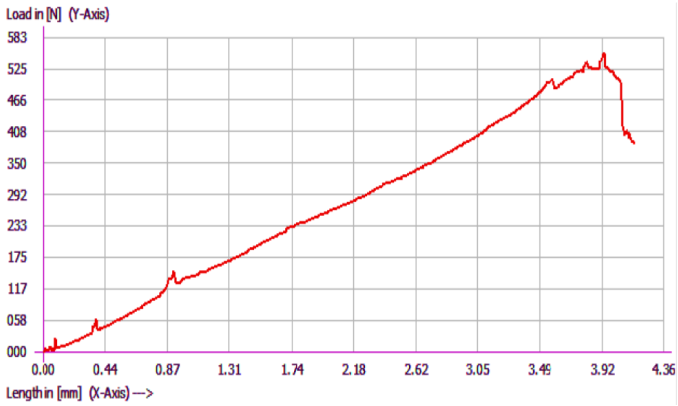

Chart -4: Carbon – Kenaf Hybrid

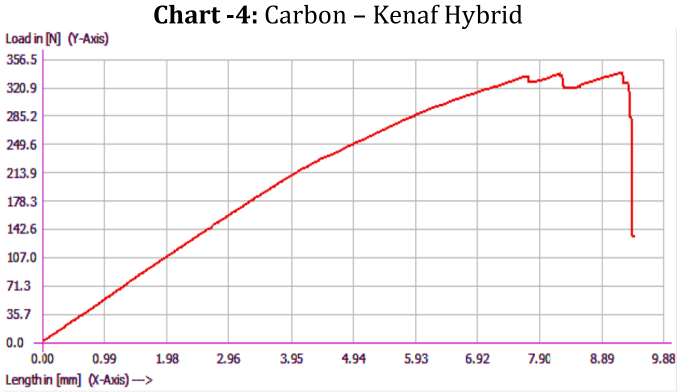

Chart -5: Carbon – E glass Hybrid

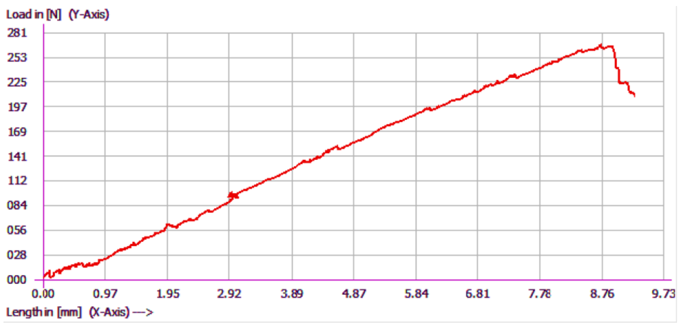

Chart -6: Carbon Fiber alone

4.3 Results and Discussion

Table -2: UTM Tensile Test Obtained Parameters

Materials Used	Peak Load (N)	% elongation	UTS (MPa)	Yield Load @ 2 (N)
Carbon - Kenaf	10060.58	4.74	167.67	5256
Carbon – E glass	9536.97	4.87	158.95	5148
Carbon alone	9004.47	4.09	150.07	5315

- From the Tensile load test results, it was found that maximum peak load was obtained for Carbon – Kenaf hybrid composite.
- UTS was also found maximum for Carbon – Kenaf hybrid compared to others.
- Yield load was higher for Carbon alone composite, but Carbon – Kenaf almost came close to that value.
- Strain was found lower for Carbon composite, but other two hybrids shows better strain value with respect to its stress value.
- Carbon - E glass hybrid shows better properties than that of carbon composite and less properties compared to Carbon – Kenaf hybrid.
- Overall tensile load test results shows hybrid composites has better properties compared to single laminated composite.

Table -3: Flexure Test Obtained Properties

Materials Used	Peak Load (N)	σ_f (MPa)	σ_c (MPa)	E_b (MPa)
Carbon - Kenaf	555.14	462.63	9.251	214191.2
Carbon - E glass	339.55	282.96	5.66	25882.41
Carbon alone	267.57	222.98	4.464	3174.54

- From Flexure test results, it was found that Carbon - Kenaf fiber composite has obtained a higher peak load.
- Also it has got higher flexural strength, compressive strength and bend modulus compared to other composites.
- It was also found that Carbon – Kenaf hybrid has got higher stress and lower strain. Therefore, it is more brittle compared to other two materials.
- Carbon – E glass also shows good properties since it has got a higher peak load than Carbon composite and better compressive stress compared to Carbon – Kenaf hybrid.

4.4 Findings

- Both tensile load test and flexure test shows hybrid composites have good properties than laminated composites.
- Both Carbon – Kenaf and Carbon – E glass hybrids have shown good strength properties, but Carbon – Kenaf shows a bit higher value compared to Carbon – E glass.
- Since the materials shows it can withstand higher stress values, it can be preferred as a replacement for materials used in high loading conditions.
- Also hybrids has a low density, which will help in creating overall light weight structure with better properties.

5. CONCLUSION

This report deals with experimental analysis data of hybrid carbon fiber composite specimen. Materials used for preparing hybrid composite were Carbon fiber twill woven, E-glass fiber and Kenaf fiber. The specimen was prepared according to ASTM standard dimensions by means of hand lay-up process.

In order to find the strength properties of the specimen, both Tensile load test and Flexure (3 point bend) test has been conducted. From the test results, it was found that hybrid materials shows very good strength value corresponds to single laminate composites. Among hybrid materials, Carbon - Kenaf exibits good load carrying capacity as well as ability to work under high stress conditions. Therefore, it can be selected as the better material.

6. SCOPE OF FUTURE WORK

Since the prepared hybrids exibits better load carrying capacity and have got high compressive as well as bending stress, this material can be preferred in wide range of applications including automobile structure. It may replace steel itself which is used as impact energy absorbers used in automobiles. More scope of the work can be predicted only after completing the numerical analysis part too.

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